Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 138 (2017) 331–336

Energy Procedia

www.elsevier.com/locate/procedia

2017 International Conference on Alternative Energy in Developing Countries and Emerging Economies
2017 AEDCEE, 25-26 May 2017, Bangkok, Thailand

Utilization of Biomass Energy in Drying of Glutinous Rice Crackers

Patipat Thanompongchart[a]*, Pakamon Pintana[a], Kajorndej Phimphilai[b], and Nakorn Tippayawong[b]

[a]Faculty of Industrial Technology, Uttaradit Rajabhat University, Uttaradit, 53000, Thailand
[b]Department of Mechanical Engineering, Chiang Mai University, Chiang Mai 50200, Thailand

Abstract

Fried glutinous rice cracker or Khaotan is a popular Thai traditional snack, which is economically important for local entrepreneurs in the north of Thailand. Drying process is an important step in acquiring good quality for final products. Without sufficient solar radiation, drying of Khaotan is usually performed in a drying cabinet with multidirectional flow of hot flue gas from burning of liquefied petroleum gas (LPG). This traditional dryer is usually inefficient. The present research work aims to improve energy efficiency and decrease operating cost of Khaotan drying by utilizing biomass energy instead of LPG. The dryer was completely re-designed and constructed with biomass combustor and flue gas to air heat exchanger. Hot air recirculation was employed as drying medium, instead of flue gas. A number of test runs were carried out on site. The dryer capacity was about 250 kg. Drying time was about 20 h to reduce original moisture content of the rice cracker from about 85-90 % dry basis to below 10 % dry basis. On average, 60-70 kg of biomass was used. Physical properties of dried Khaotan being analyzed were color, shrinkage ratio, expansion ratio, hardness and crispness. From the findings, while the product quality was similar, the energetic analysis results were better than those fueled by LPG. Energy consumption and operating cost of the biomass fired, hot air dryer were lower.

Keywords: Biomass energy, Drying process, Hot air oven, Food quality, Khaotan dryer.

* Corresponding author. Tel.: +6-686-671-7937.
E-mail address: patipat.than@gmail.com

1876-6102
10.1016/j.egypro.2017.10.131

Nomenclature

E	electrical energy used (*J*)
L	latent heat of evaporation for water (*J/kg*)
LHV	lower heating value for fuel (*J/kg*)
m_f	mass of fuel used (*kg*)
m_p	mass of dried Khaotan produced (*kg*)
m_w	mass of moisture loss produced (*kg*)
SEU	specific energy utilisation (*J/kg*)
η	thermal efficiency (*%*)

1. Introduction

Fried glutinous rice cracker or Khaotan is a traditional and popular snack in the northern part of Thailand. It is also a geographical indication product of Lampang province. From a tradition snack of local Thai communities, it has become an economically important product of the country and is exported to the world. Khaotan is made from glutinous rice and topped with flavorings like cane juice. Now, the rice cracker has been developed to many flavors and shapes to support consumers' demand [1]. In the production process, drying is an essential step to high quality products. Suitable moisture content of the rice cracker should be around 8-10 % dry basis [2, 3]. High moisture content will lower its storage life, whereas low moisture content will lead to possibility of damage or defects during frying process. Depending on drying methods, it can be challenging to obtain final moisture content of product. Generally, direct solar radiation is used for reducing moisture content. The advantage of direct solar radiation is free energy but it relies on nature and weather conditions and is prone to be contaminated by dust, insects, etc. Indirect solar drying or greenhouse or solar dome dryer use free energy but has high investment and relies on sun light. Typical dryers using liquefied petroleum gas (LPG) consume high energy thus high operational cost [4, 5].

From above limitation of traditional drying methods, an alternative method to reduce operating cost and conserve quality of dried Khaotan is needed. Biomass from agriculture wastes are best for renewable energy because it is relatively low price and available locally [6]. Biomass fired dryer may be a good option. It may consist of furnace and heat exchanger designed to be used with biomass energy. In this work, the objectives were to reduce operating cost of Khaotan drying process, and to analyse the physical property, energetic efficiency, simple economic analysis. Experimental data obtained from the proposed dryer is presented and compared with traditional dryers.

2. Methodology

2.1 Biomass fired dryer

The biomass fired, hot air dryer was designed, built and tested. The dryer consists of two parts, (i) biomass furnace and heat exchanger as heat generation zone and, (ii) product loading chamber as drying zone. The configuration of the dryer is shown in Fig. 1(a). The cabinet size is 6 m long, 4 m wide and 1.8 m high. Walls and ceiling of the drying cabinet were made from galvanized iron sheets covered with 10 cm thick of insulation foam. A fan used to distribute hot clean air thru a tube bundle heat exchanger to the drying zone was driven by a 0.5 horse power motor and air velocity could be adjusted by a speed controller. The heat exchanger connected with the biomass fired furnace was used to transfer heat from flue gas to clean air. The furnace and heat exchanger are depicted in Fig. 1(b). A swing panel was installed between the heat generation zone and drying zone to control the distribution of air flow and to prevent any dead zone in the drying chamber. Heating value of the biomass used was 12 MJ/kg [7]. A total capacity of the cabinet was about 250 kg/batch. Air temperature was varied depending on biomass feeding rate and air velocity. However, the air velocity used was approximately at 1 m/s on average, distributed uniformly across the cross-section of the drying chamber [8, 9]. Major bulk of hot air was recirculated. There were two large apertures